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Wackerle

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[54] **METHOD AND APPARATUS FOR A CONTINUOUS FLUID TREATMENT OF FIBROUS MATERIALS**

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[51] **Int. Cl.** **B05c 3/04,** B05c 3/132

[58] **Field of Search** .... 8/156, 151; 68/43, 68/97, 98, 99, 100, 175, 184, 22 B; 19/200

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[57] **ABSTRACT**

In treating fibrous materials with a fluid medium, such as for cleaning or impregnating the fibers, the material is moved along a path of travel through a chamber in which the fluid medium flows under pressure in a vortical pattern. Due to the vortical flow, the fluid medium flows in counterflow relationship to the fibrous material for at least a part of its path of travel through the chamber. Further, at the same time it passes in counterflow relationship, the fluid medium also flows transversely into the fibrous material. The chamber can be defined laterally by two pairs of vertically extending rotating rolls. The rolls in one pair are spaced apart and form an inlet gap through which the fibrous material passes into the chamber, while at least one of the rolls in the other pair has a circumferentially extending groove through which the material exists from the chamber. The rolls in each pair rotate in opposite directions to one another in developing the vortical flow of the fluid medium.

23 Claims, 3 Drawing Figures

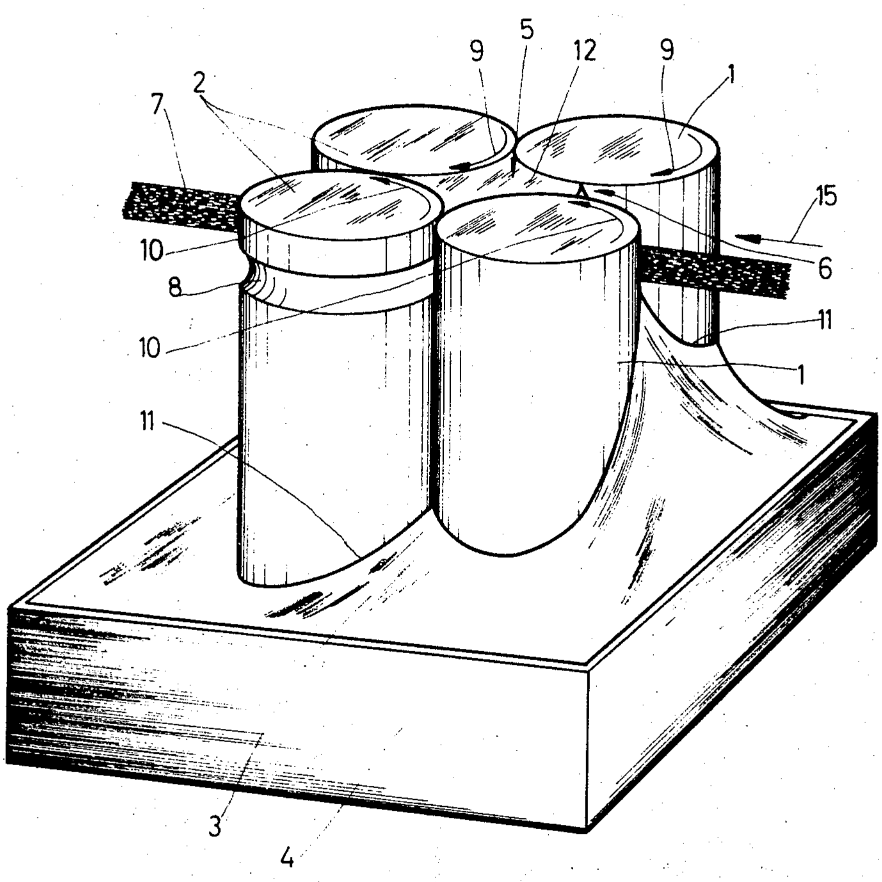


Fig. 1

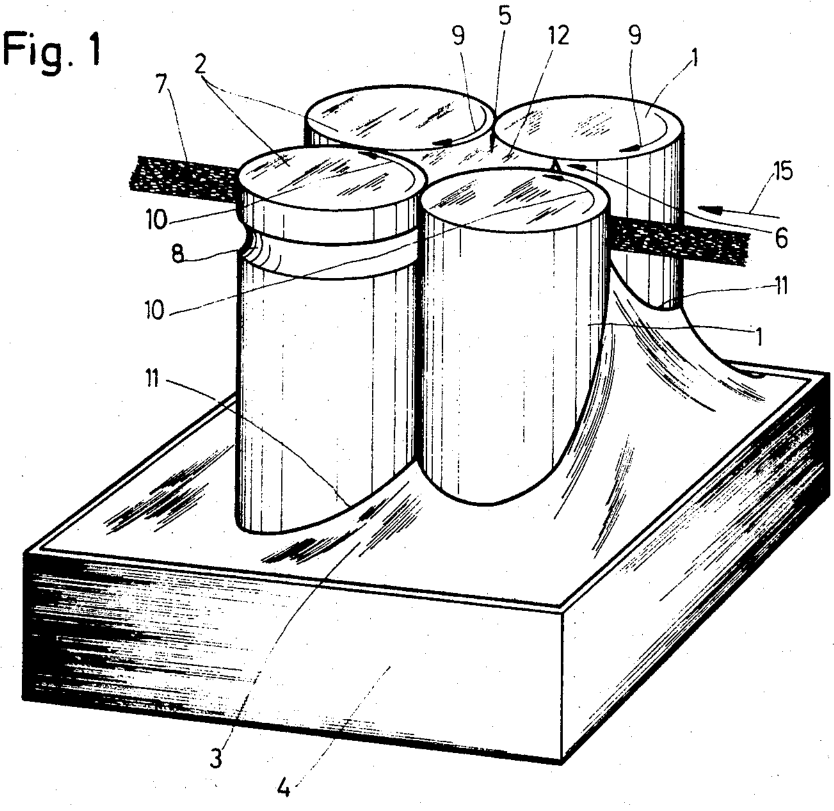


Fig. 3

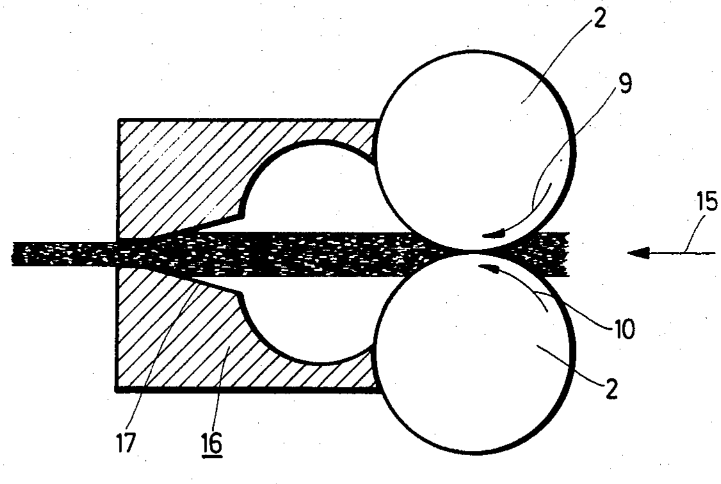
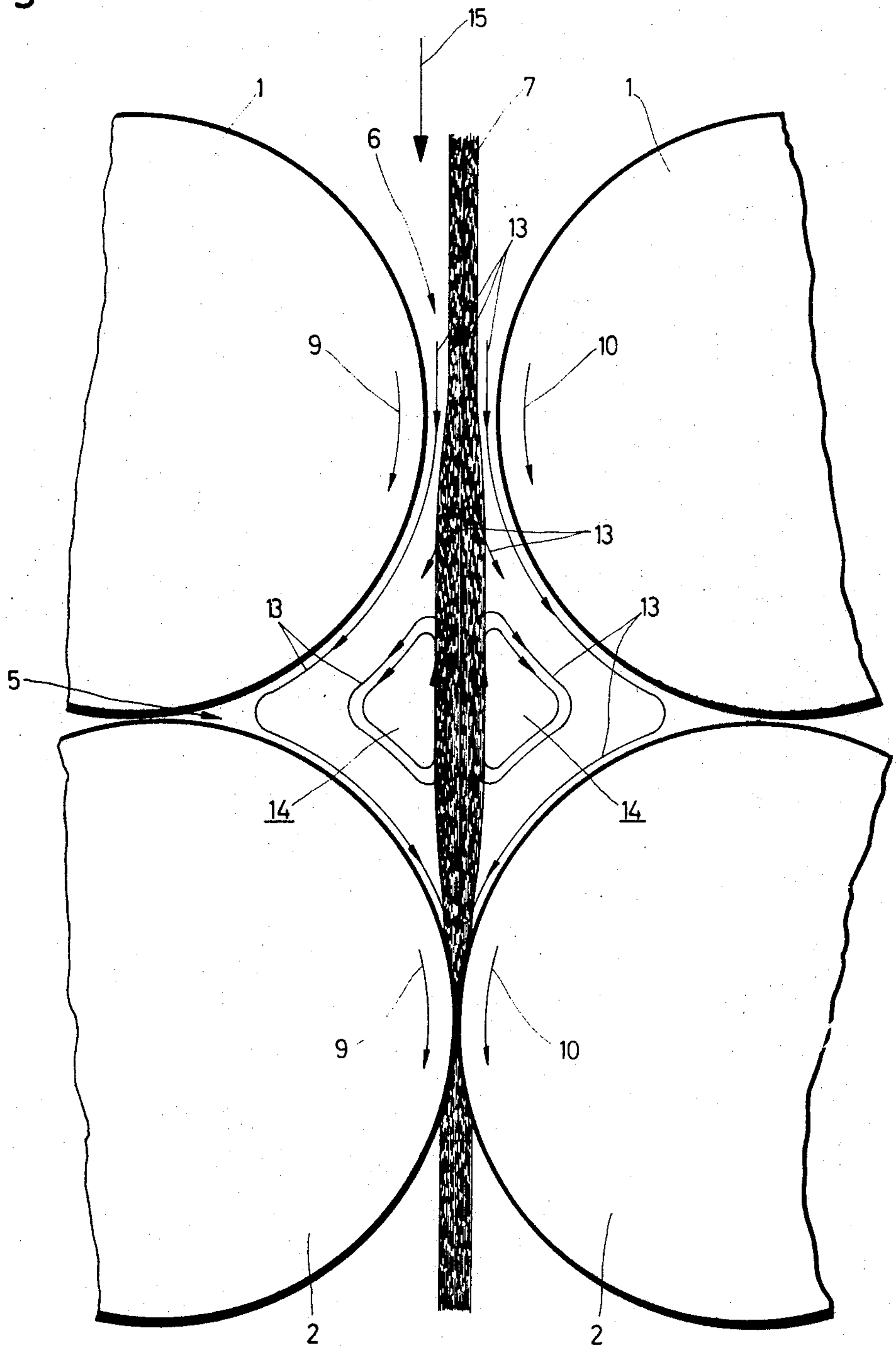


Fig. 2



METHOD AND APPARATUS FOR A CONTINUOUS FLUID TREATMENT OF FIBROUS MATERIALS

SUMMARY OF THE INVENTION

The present invention is directed to a method of an apparatus for continuously treating fibrous materials with a fluid medium and, more particularly, it concerns the formation of a vortical flow in the fluid medium through which the fibrous material passes.

In the wet treatment of spun fibers or threads or of structures or materials formed of such filamentary elements, it has been known to pass the material to be treated through impregnating agents, such as oils, water, starches, plastics, synthetic resins and the like. Such liquid or fluid treatment of fibrous materials has been carried out in a liquid bath or by a spraying operation. However, when spraying is used, the wetting action on the fibrous materials is incomplete or irregular. When the fibrous materials are passed through a bath, the wwetting action is improved, however, it is less effective within the interior of the fibrous material, such as in a bundle of threads or fibers, and, in addition, air contained within the bundle is difficult to displace. When liquid baths are used deflection guides are required to conduct the fibrous material through the bath and, as a result, damage to the fibrous material occurs because of friction and it is difficult to avoid such damage. As a rule, it has been necessary to carry out the treatment of the fibrous material at low velocities in such known treatment operations.

Therefore, it is the primary object of the present invention to provide a continuous treatment of fibrous materials with a liquid or fluid medium as the fibrous materials move through a chamber in contact-free relationship with the surfaces defining the chamber. The treatment affords a uniform wetting action of all of the fibrous material while maintaining the air bubble content of the material at a low level.

Another object of the invention is to conduct the fibrous materials through the treatment chamber at a higher velocity than has been possible in the past, for instance, when the fibrous materials were passed through a bath containing a stagnant liquid.

Still another object of the invention is to provide a treatment which is suitable for any fibrous material irrespective of the impregnating properties of the material. This treatment is equally applicable to vegetable and animal fibers as well as to fibers of a chemical or mineral origin.

Moreover, another object of the invention, is to afford an apparatus for carrying out the treatment which is simple in design and compact in arrangement.

In accordance with the present invention, the fibrous material is passed through a chamber where it is treated with a fluid medium flowing, at least in part, in counterflow relationship with the fibrous material and, at the same time, flowing transversely into the fibrous material. The pressurized flow of the fluid medium can be provided by imparting a vortical flow to the fluid medium, such as by providing surfaces bounding the fluid medium within the chamber so that the surfaces contribute to the vortical flow. In one arrangement two pairs of rotating rolls can be arranged with their axes extending in parallel relationship to one another and transversely of the path of travel of the fibrous material so that the rotation of the rolls develops vortices within the fluid medium. Alternatively, the chamber containing the fluid can be provided with surfaces which develop a single vortex in the fluid medium with the vortex arranged to provide the counter-and transverse flow of the fluid medium relative to the fibrous material.

Preferably, the vortical flow revolves in the direction opposite to the direction of movement of the fibrous material along its path of travel. When one or two vortices are provided in the fluid medium, the fibrous material formed of filamentary elements is first fanned out as the fluid medium passes in the direction of movement of the fibrous material followed by the vortical flow which directs the fluid medium in counter-and transverse flow through the material and then as the fibrous material continues along its path of flow within the chamber it is returned to its original form. Due to the high pressure in the boundary region of the vortical flows, the fluid medium passes through the fibrous material in a transverse direction. As a result of the different flow components of the fluid medium relative to the fibrous material, as well as to the pressure developed in the fluid medium, the content of air bubbles within the maerial will be kept at a low level and, because of the intensive flow of the fluid medium, it is possible to conduct the fibrous material through the treatment chamber at high velocities.

Another advantage of the resent invention is the provision of the fluid medium in a columnar form through which the fibrous materials can pass without deflection. This form of wet treatment of the fibrous materials is effective regardless of the form in which the materials, whether filamentary or band-shaped, are provided. Further, the treatment is equally suitable for cleaning and for impregnating fibrous materials.

In a structural embodiment of the invention, two pairs of rolls are provided,positioned within a container,and arranged to define a chamber between their surfaces. The rolls are arranged in lateral relationship with their axes disposed in parallel relationship and, further, one pair of the rolls are spaced apart for defining an inlet gap into the chamber within the rolls in which the vortical flow of the fluid medium takes place. In this apparatus the pairs of rolls are positioned within a container or tank which holds the fluid medium as the rolls are rotated, with the rolls in each pair rotating in opposite directions so that they rotate in the direction of passage of the fibrous material through the chamber formed within the rolls, the liquid within the tank is lifted upwardly and directed through the gap between the upstream pair of rolls and, within the chamber between the rolls, two vortices are formed each rotating in opposite directions on the opposite sides of the fibrous material passing therethrough. In addition to the vertically arranged rolls, the chamber formed between the rolls can also have upper and lower horizontal boundary surfaces. In such a case the vortices within the chamber form a liquid column of high pressure, depending on the viscosity of the fluid medium and also on the feeding action of the rolls. within the chamber formed between the rotating roll surfaces the fluid medium, due to its vortical action, is directed back through the fibrous material toward the inlet gap in the boundary space between the two vortices. After its countercurrent flow through the fibrous material toward the inlet gap the action of the rotating rolls again defects the fluid medium into the vortical path.

To obtain the desired effect on the fibrous materials to be treated, they must be passed through the boundary region between the vortices or through the boundary region of the single vortex. Accordingly, the downstream pair of rolls defining the chamber afford only a narrow outlet gap for the material with the extent of the gap dependent on the form of the fibrous materials are in a filamentary form as they being treated. Where the fibrous materials are in a filamentary form as they pass through the chamber, the outlet gap can be eliminated and in its place at least one of the rolls can be formed with a circumferentially extending groove through which the fibrous materials can pass. In such an arrangement the downstream pair of rolls can rotate in contact with one another at their peripheries so that the excessive outflow of the fluid medium from the chamber is prevented.

The various features of novelty which characterize the invention are pointed out with particularity in the claims annexed to and forming a part of this disclosure. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawings and descriptive matter in which there are illustrated and described preferred embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawing:

FIG. 1 is a perspective view of one embodiment of the present invention showing the path of travel of the fibrous material;

FIG. 2 is an enlarged partial top view of the arrangement shown in FIG. 1 in which the rolls are shown defining a vortex chamber; and

FIG. 3 is a top view of a pair of the rolls, such as shown in FIGS. 1 and 2, with a tank, shown in section, adjacent the outlet from the rolls.

DETAILED DESCRIPTION OF THE INVENTION

In FIG. 1, a tank 4 is shown partly filled with a liquid 3, for simplicity's sake, only the lower portion of the tank is represented. Within the tank 4 a first pair of vertically extending rolls 1,1 and a second pair of vertically extending rolls 2,2 are arranged to rotate about their vertical axes which are all disposed in parallel relationship. The upper part of the tank,which is not shown,forms a lid and at the same time serves as a cover for a chamber 5 defined by the inwardly facing surfaces of the two pairs of rolls. Accordingly, both pairs of rolls 1,1 and 2,2 extend upwardly to the surface of the lid and packing material, for example, O-rings, are arranged between the ends of the rolls and the lid. Further, with regard to the support of the rolls 1,1 and 2,2 it should be noted that they can be connected at their upper ends with shafts extending through the lid and at their lower ends the rolls can be supported by so-called stop balls. The shafts provided through the top of the tank afford the rotational movement of the rolls 1,1 and 2,2.

As can be seen in FIG. 1, a bundle or band of fibrous material 7, which may be formed of individual longitudinally extending filamentary elements, passes along a rectiliner path of travel through the tank 4, passing first between the first pair of rolls 1,1 and then through the second pair of rolls 2,2. As shown in FIG. 2, the rolls 1,1 in the first pair are spaced laterally from one another forming an inlet gap 6 into the chamber 5 defined by the oppositely disposed surfaces of the rolls which face inwardly toward the bundle 7 of fibrous material. Further, as indicated in FIG. 2, the rolls 1,1 are positioned very closely from the corresponding rolls 2,2 and the rolls 2,2, defining the outlet from the chamber ,are in contact with one another for limiting the outflow from the chamber. However, a circumferentially extending groove extending radially inwardly from the surface of at least one of the rolls 2 forms an outlet passage through which the bundle of fibrous material 7 exits from the chamber 5. The form or shape of the outlet provided by the groove 8 is adapted to the cross sectional configuration of the bundle or other shape of fibrous material passing through the chamber. Furthermore, several such outlet passages can be provided from the chamber. As indicated above, the rolls 1,1 in the first pair are spaced closely from the rolls 2,2 in the second pair so that they can rotate without friction, but the gap width is kept small to minimize any leakage which might affect the flow within the chamber 5.

In FIG. 2 the pattern of flow within the chamber 5 is indicated, the fibrous material 7 is introduced into the chamber in the direction of the arrow 15 passing through the inlet gap 6 formed between the laterally spaced rolls 1,1. To effect the flow of the fluid medium each of the rolls is rotated, such as by the shafts which pass through the lid of the tank 4 which shafts are in connection with chain drives or the like. O one side of the fibrous material, rolls 1, 2 are rotated in the direction of the arrows 9 while on the opposite side of the fibrous material the rolls 1,2 are rotated in the direction of the arrows 10,10. It will be noted that the rolls rotate in the direction of the path of travel of the fibrous material through the chamber 5 as indicated by the arrow 15. Due to the rotation of the rolls the fluid medium within the tank is drawn through the inlet gap 6 into the chamber 5 and, in providing the desired flow characteristics,the rolls 1,1 can be rotated faster than the rolls 2,2 located downstream from them in the direction of travel of the fibrous material. Due to the action of the rolls, the liquid level in the range of the rolls 1,1 and 2,2 located outside the chamber 5 is lifted in a form corresponding to that shown by the line 11 in FIG. 1. As a result, the level of the fluid medium, that is the liquid within the tank, is higher adjacent the rolls than at the inner walls of the tank, as mentioned above. In FIG. 1 only the lower portion of the tank is shown. Due to the rotation of the rolls, a liquid column 12 of increased pressure is formed in the chamber 5, that is within the space defined by the inwardly facing surfaces of the four rolls, and within the chamber the flow or current generated within the fluid medium follows the course substantially indicated by the arrows 13, note FIG. 2. Accordingly, two vortices 14, each on an opposite side of the fibrous material 7, is formed within the chamber 5 each rotating oppositely about its core axis relative to the other. In the boundary region of the two vortices through which the fibrous material passes the current or flow is directed in countercurrent flow relationship to the direction of travel of the fibrous material. As the fluid medium flows toward the inlet gap 6 it is again deflected by the rotation of the rolls 1,1 and continues to flow in the pattern indicated in FIG. 2. As illustrated in FIG. 2, the fibrous material passes through the inlet gap 6, out of contact with the rolls 1,1 and passes in countercurrent flow relationship with the fluid medium in its vortical fow pattern. Due to the action of the fluid medium within the chamber **5**, the bundle of fibrous material is fanned out as it passes through the inlet gap **6** and the fluid medium flows in the longitudinal direction through the bundle until it is again deflected by the rotation of the rolls which generate the vortical action. Due to the vortical flow of the fluid medium in both of the vortices **14** and because of the pressure generated within the fluid medium, there is a transverse flow into the bundle of fibrous material **7** which is in its fanned-out form as it passes through the boundary regions of the vortices **14**. With the intensive flow of the medium through the fibrous material it is practically impossible for any air to remain within the material.

As the bundle of fibrous material **7** approaches the rolls **2,2** it is returned to its original form by the action of the flow of the fluid medium at that location. As the fibrous material exits from the chamber **5**, it is directed through the passage defined by the grooves **8** formed in the circumferential periphery of the rolls **2**.While it is possible for the liquid to escape from the chamber passing between the corresponding surfaces of the rolls **1,2** located on the opposite sides of the chamber as well as through the outlet formed by the grooves **8**, the loss of liquid is relatively small and it has been found that the loss has no marked effect on the flow generated in the liquid **12**. Tests with a synthetic resin for impregnating the fibrous material **7** have shown that gaps can be located between the rolls **1,2**, depending on the viscosity of the treating medium and the circumferential speed of the rolls. A slightly larger gap can be provided between the rolls **2,2** than between the rolls **1,2** depending on the form of the fibrous material being treated, for example, so that band-shaped fibrous material can be directed between the rolls in contact-free relationship with them.

If the method of the present invention is used in the apparatus described above and is used for impregnating fibrous materials, the materials can be passed through the chamber or impregnation zone between the rolls **1,1** and **2,2** at a relatively high speed and it will still be possible to effect the impregna-tion in a uniform manner. Another characteristic advantage of the invention is the ability to carry out the treatment of the fibrous materials, particularly sensitive fibrous materials, without the use of deflection guides. This feature is of special importance in treating graphite fibers which are usually impregnated with a synthetic resin before they are processed further, for example, for the production of fiber-reinforced plastics.

It is also possible to use this fiber treatment operation for washing substances from the fibrous material which already exist in solution within the material, for example, non-fixed dyes and the like,or for rinsing out loose particles, such as impurities.

While only two pairs of rolls **1,1** and **2,2** have been shown in the drawing, it will be appreciated that additional rolls could be arranged downstream of the rolls **2,2** for affording additional treatment chambers. Alternatively, instead of using the second pair of rolls **2,2**,a stationary plane surface containing an outlet for the fibrous material could be used in their place, or one each of the rolls **1,2** could be replaced by a plane surface by the series arrangement of a plane surface and a revolving roll having a larger diameter. In these alternative arrangements, only a single vortex would be generated by the rotating action of the rolls and the fibrous material **7** would be passed through the boundary region of the vortex and the stationary plane surface or larger revolving roll.

It is not necessary for the vortices generated within the chamber **5** to be induced by the movement of the boundary surfaces of the chamber, that is by the rolls, as has been described above, rather the vortical flow can also be effected by the configuration of the surfaces enclosing the treatment chamber. Such surfaces can be provided as parts of rotating circular cylindrical rolls or parts of other axially symmetrical bodies, for example, bodies having the form of double cones, truncated cones, and the like. In such an arrangement, the vortices are formed in chambers which are open along one side, the treating vortex can be bounded by another vortex in the range of the open side or, alternatively, by a rotating roll, a plane surface and the like. In such arrangements, the fibrous materials would be directed through the boundary regions of the vortex or vortices. Another manner of producing the vortical flow can be provided by directing the flow of the fluid medium so that it contacts the vortex in a tangential manner. Preferably, when such flow is used in developing the vortical pattern, it is a pressurized flow which can be variable.

Accordingly, it can be appreciated that the present invention is not limited to the specific apparatus illustrated in FIGS. **1** and **2**, however, such apparatus has been found to be particularly appropriate in carrying out this type of wet treatment. In another arrangement it is possible, in a very simple manner, to effect a degasification after the fibrous material has passed through the wet treatment chamber. As indicated in FIG. **3**, a degasification tank **16** is arranged downstream of the rolls **2,2** and a vacuum or underpressure is produced within the tank. Accordingly, the contact surfaces between the rolls **2,2** and the tank wall would be sealed by packing material, such as O-rings. As the fibrous material **7** passes through the tank **16** any air bubbles contained within the material are removed. Liquid entering the tank from the treatment chamber **5** due to the vacuum within the tank, can be eliminated by means of a vacuum line, not shown. Preferably, the outlet from the degasification tank is designed as a drawing nozzle. However, in place of the drawing nozzle, two oppositely rotating rolls provided with soft surfaces which provide a sealing effect, because of the vacuum, could be used and a calibratin effect afforded for the liquid content of the fibrous material **7**. Further, it should be noted that additional heat treatment of the fibrous material along its length would also be possible.

While specific embodiments of the invention have been shown and described in detail to illustrate the application of the inventive principles, it will be understood that the invention may be embodied otherwise without departing from such principles.

What is claimed is:

1. Method for continuously treating moving fibrous material with a fluid medium,comprising moving the material through a treatment chamber along a path of travel, directing the fluid medium under pressure in contact with the moving fibrous material along its path of travel so that for at least a portion of the length of contact between the fluid medium and the fibrous material the fluid medium flows in counterflow relationship with the fibrous material and at the same time

flows transversely of the direction of the path of travel into the fibrous material.

2. Method, as set forth in claim 1, characterized therein by conducting the fibrous material through the treatment chamber in a contact-free manner from the surfaces defining the chamber.

3. Method, as set forth in claim 1, characterized therein by initially directing the flow of the liquid medium in parallel flow relationship with and in the same direction as the path of travel of the fibrous material prior to effecting the counterflow relationship.

4. Method, as set forth in claim 1, characterized therein by providing the counterflow and simultaneous transverse flow by imparting a vortical flow to the fluid medium and directing the fibrous material through the boundary region of the vortical flow.

5. Method, as set forth in claim 4, characterized therein by providing two vortical flows of the fluid medium with the core axes of the two vortical flows disposed in laterally spaced parallel relationship lo each other and with the axes disposed transversely of the path of travel of the fibrous material, and arranging the two vortical flows relative to the fibrous material so that the fibrous material passes through the adjacent boundary regions of the two vortical flows.

6. Method, as set forth in claim 5, characterized therein by rotating the vortical flows in opposite directions about their core axes so that the boundary surfaces thereof contacting the fibrous material flow countercurrent to the path of travel of the fibrous material.

7. Method, as set forth in claim 4, characterized therein by providing a solid surface bounding the vortical flow and directing the fibrous material between the solid surface and the boundary region of the vortical flow.

8. Method, as set forth in claim 4, characterized therein by inducing the vortical flow by supplying a flow of the fluid medium so that the flow induces the vortical action.

9. Method, as set forth in claim 8, characterized therein by inducing the vortical flow by directing a pressurized flow of the fluid medium tangentially to the boundary of the vortical flow.

10. Method, as set forth in claim 4, characterized therein by inducing the vortical flow by directing flow of the fluid medium over surfaces defining the boundaries of the vortical flow.

11. Method, as set forth in claim 4, characterized therein by inducing the vortical flow by rotating the surfaces of the treatment chamber which bound the vortical flow.

12. Method, as set forth in claim 1, characterized therein by employing filamentary fibrous materials.

13. Method, as set forth in claim 12, characterized therein by utilizing carbon-containing fibrous materials.

14. Method, as set forth in claim 1, characterized therein by effecting impregnation of ghe fibrous materials within the treatment chamber.

15. Method, as set forth in claim 1, characterized therein by effecting a cleaning action of the fibrous materials within the treatment chamber.

16. Apparatus for continuously treating fibrous materials with a fluid medium,comprising means forming a chamber containing the fluid medium, said means including at least one axially extending rotatable member for imparting a vortical flow to the fluid medium within said chamber, and said means providing an inlet gap for introducing the fibrous material into said chamber for passage along a path of travel extending transversely of the axis of said rotatable member.

17. Apparatus, as set forth in claim 16, wherein said means forming said chamber comprises a first pair and a second pair of vertically arranged rolls with the rolls in each said pair being disposed laterally relative to one another, the axes of said first and second pairs disposed in parallel relationship, said second pair of rolls spaced in the downstream direction of the path of travel of the fibrous material from said first pair of rolls, and in said first and said second pairs of rolls each said roller is arranged to rotate in the opposite direction relative to the other said roll in said pair.

18. Apparatus, as set forth in claim 17, wherein said rolls in said first pair of rolls being spaced apart at their adjacent circumferential peripheries for forming an inlet gap into said chamber.

19. Apparatus, as set forth in claim 17, wherein said means further comprises horizontal wall members extending transversely of said first and second pairs of rolls at the opposite ends thereof.

20. Apparatus, as set forth in claim 17, wherein at least one of said rolls of said second pair of rolls has a circumferentially extending groove formed radially inwardly into its circumferential peripheral surface for forming a passage between said second pair of rolls for the fibrous material exiting from said chamber.

21. Apparatus, as set forth in claim 17, wherein a degasification tank is positioned downstream from said second pair of rolls and is located in the path of travel of the fibrous material after it leaves said chamber.

22. Apparatus, as set forth in claim 17, wherein a drawing nozzle is positioned downstream relative to the path of travel of the fibrous material from said second pair of rolls.

23. Apparatus, as set forth in claim 21, wherein said second pair of rolls form the inlet side of said degasification chamber and are in sealing contact with said degasification chamber.

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